Exhibit A

Project Scope of Work and Budget

Introduction

The following scope of work is presented as the proposed work plan for the TRM Service Bureau and Model Team for the budget year July 1, 2014 – June 30, 2015. The primary efforts outlined in this scope are intended to focus the efforts of the Service Bureau and Model Team on completing development of a v6 model for the Triangle region with various enhancements. During this budget year work will continue on investigations for developing a future v7 model. Refer to Appendix A for an overall vision for v6 and v7 models.

Several assumptions are made within the context of this scope.

1. Each signatory agency's one half FTE contribution may include staff time from people other than their TRM Team member, but the TRM Team member will play a key role and other staff must be adequately trained to meet the needs of the TRM Team.
2. All TRM staff representing the signatory agencies will, as needed, work on site at ITRE, including any third person who is providing services in the name of a signatory agency. This enables the Team to work together on issues that require the input of multiple team members and reduces the tendency for team members to be reassigned to other tasks in their home offices.
3. The TRM Program Manager will assign tasks with associated deliverables and target dates. TRM Team members will agree to take responsibility for specific tasks and will be held accountable for completion of those tasks. The responsible team member (stakeholder and TRM Service Bureau) will be responsible for **monthly** reporting on progress via an email attachment including 1) status, 2) changes in anticipated completion dates, 3) reasons for change, and 4) hours spent on model development work for the month reported.
4. Signatory agencies will commit one half FTE per agency to the completion of the list of tasks outlined in this work plan. The TRM Program Manager will assume responsibility for providing adequate work to meet this obligation by specifying the task description, deliverables, and person hours required. This information will be provided at least quarterly and will be sufficient to fully incorporate the one half FTE required of each agency.
5. All intermediate and final products of this work program belong to the four stakeholders (NCDOT, CAMPO, DCHC, and Triangle Transit) and these will be delivered to the stakeholders in a form and via media acceptable to each stakeholder at the end of the contract year or before. The products include: model files including input files; scripts and program source code; all technical memoranda; estimation data file inputs and outputs; technical reports and user guides.

Note on model version names: the following version names will be used in this scope of work consistent with model team recommendations (for detailed TRM name history, please refer to Appendix B "TRM History" section).

- **TRM v5:** Based on structure of v4-2008 with revisions to model specifications and using 2006 household survey and 2006 on board transit survey data for estimating model components with an expanded study area [v5 TAZ system]. The enhancements requested by the stakeholders have been included. (see Appendix B "TRM History" for detailed list of enhancements) This version will be used for the Alternatives Analysis and Air Quality Conformity Analysis for the 2040 Long Range Transportation Plans.
- **TRM v6:** Updated and enhanced trip based model based on the v5 model. TRM v6 (with a 2010 estimation year, and 2013 base year) will be delivered in

December, 2014 and will be used for the Alternatives Analysis and Air Quality Conformity Analysis for the 2045 Long Range Transportation Plan.

- **TRM v7:** New tour based or activity based model designed to address policy testing needs not sufficiently addressed by TRM v6. TRM v7 will be delivered in December, 2018 and will be used for the Alternatives Analysis and Air Quality Conformity Analysis for the 2050 Long Range Transportation Plan.

Overall Work Program Summary Task Table (including stakeholder work hours)

Task Number	Task Title	Task Hours	% of Total
1.1	Advice and management of parking beh. data collection	152	1.5%
1.2	Household survey data collection	472	4.8%
1.3	Transit on-board survey data collection	264	2.7%
1.4	Gather locally collected data	280	2.8%
2.1	Maintain and update hwy. & transit networks, SE data	1,696	17.1%
2.2	Modify Net Manager to work with v6 model networks	120	1.2%
2.3	Zone geography	0	0%
2.4	Develop highway network procedures	0	0%
2.5	Transit networks	0	0%
2.6	Zonal data & models	320	3.2%
2.7	Develop an improved parking constraint model	1,456	14.7%
2.8	Data systems	320	3.2%
3.1	Re-estimation and/or re-calibration of trip production models	0	0%
4.1	Peak spreading model	0	0%
5.1	Develop an improved destination choice model	0	0%
6.1	Estimation and calibration of non-motorized models	0	0%
7.1	Calibration of mode choice models	0	0%
8.1	Develop improved commercial vehicle model (CVM)	0	0%
8.2	University student model	80	0.8%
8.3	Land use models	0	0%
8.4	External travel models	184	1.9%
8.5	Links to MOVES air quality models	176	1.8%

Task Number	Task Title	Task Hours	% of Total
8.6	Sub-area and corridor analysis procedures	200	2.0%
9.1	Investigate improving hwy assignment	0	0%
9.2	TRM v6 model assignment & overall model calibration	1,424	14.3%
10.1	TRM v6 documentation	240	2.4%
11.1	Assist with MTP model application	80	0.8%
11.2	Assistance with TRM model application	160	1.6%
11.3	Action items	424	4.3%
12.1	Oversight and reporting	1,608	16.2%
12.2	Training	280	2.8%

1 Data collection

1.1 *Advice and management of parking behavior data collection*

Parking related behavior data will be collected for later use in developing the models designed in FY 13. This task was deferred at stakeholder request during FY 2014 to be completed during FY 2015.

Deliverables:

A. By survey consulting firm:
   1) Survey designs (sample plan, instrument etc.)
   2) Pilot survey report on details and issues
   3) Full survey report (usual survey contents)
   4) Complete final cleaned/Geo-coded full survey and pilot survey data, fully expanded/weighted, ready to use; with complete data dictionary
   5) Working data used (including but not limited to recruitment data, expansion/weighting source data and working files)
   6) Training session for stakeholders

B. By TRM team:

Technical memoranda on

   1) Stakeholders review and approve survey sampling plan including parking facilities in each PASA to be surveyed, because the survey is not expected to be a simple random sample
   2) Pilot survey procedure/instrument and data QA/QC issues and suggested resolution
   3) Pilot survey data analysis result
   4) Full survey data QAQC issues and resolutions

Est. start date: 7/1/2014

Est. end date: 10/25/2014

ID	Task Description	Person Days
1.1	**Parking behavior data collection management**	**19**
b)	Design and review data collection procedure	1
c)	Design and review sample plan including team member review	3
d)	Design and review survey instruments	2
e)	Review preliminary design for stakeholders approval	1
f)	Management of pilot data collection [including but not limited to signing contract, overseeing survey consulting firm process, communication, issue resolving, budget/time control]	1
g)	QAQC and analyze pilot data; provide feedback to survey consultant and document	4
h)	Advice for management of full data collection [including but not limited to overseeing survey consulting firm process, communication, issue resolving, budget/time control; final training]	2
i)	QAQC full survey data; provide feedback to survey consultant and document	5

** Note: This effort estimate assumes a one for one matching effort will be provided by the stakeholder that contracts for survey data collection*

1.2 *Household survey data collection*

A household survey is anticipated to be conducted by the region to support future model development efforts. A sample of households for the region is expected to be surveyed during 2015. This task will develop a recommended survey approach, provide a basis for developing a request for proposals document, and manage survey data collection by a contractor.

Deliverables:

Technical memoranda on:

a) Recommended study area and sample plan, recommended approach to survey households including survey instrument design, GPS add-on, and cost estimate for survey

b) Request for proposals document

c) Documented procurement process

d) Review of pilot survey design

By contractor:

a) Recommended sample plan, survey approach and survey materials

b) Pilot survey report and recommendations for full survey

Est. start date: 7/1/2014

Est. end date: 6/30/2015

ID	Task Description	Person Days
1.2	**Household survey data collection management**	**59**
a)	Develop recommended study area, number of samples, and cost estimate for stakeholder review and approval	3
b)	Design and review of data collection approach for including in RFP document	2
c)	Obtain recent RFPs for surveys in other regions	1
d)	Prepare draft request for proposals for review	5
e)	Team review of draft request for proposals & review meetings (2x)	14
f)	Prepare Institutional Review Board review package before procurement	1
g)	Conduct procurement of survey contractor (including proposal review & firm selection by Model Team & stakeholders)	15
h)	Oversee data collection efforts of contractor for pilot survey including Model Team and IRB review of survey materials and approach	18

1.3 *Transit on-board survey data collection*

A transit on-board survey of passengers is anticipated to be conducted by the region during 2015 to support model development.

Deliverables:

Technical memoranda on:

a) Recommended approach for surveying transit services in the region including a description of services to be sampled and elements of questionnaire design (interview or self-administered), and cost estimate for survey

b) Draft request for proposals document

c) Documented procurement process

Est. start date: 7/1/2014

Est. end date: 6/30/2015

ID	Task Description	Person Days
1.3	**Transit on-board survey data collection management**	**33**
a)	From 2013 base year transit services and any available information for 2015 estimate the number of routes to survey and prepare a cost estimate	2
b)	Obtain RFPs for on board surveys from Triangle and other regions	1
c)	Prepare draft request for proposals document for stakeholder review and approval	5
d)	Team review of draft request for proposals & review meeting	10
e)	Conduct procurement of survey contractor (including proposal review & firm selection by Model Team and stakeholders)	15

1.4 *Gather locally collected data*

Stakeholders and local governments routinely collect many types of data that could be used for developing the TRM, such as traffic counts, turning movement counts, and transit passenger counts. In order to use the locally collected data for developing the TRM, it needs to be gathered from the agencies that collect it, to organize it for use, and to document it. This task will contact local agencies and compile a catalog of locally collected data including contact information and information about when and how often data is collected. A set of file folders will be created to organize the data, and to make it easy for team members to find it. Finally documentation will be prepared for the data gathered.

Deliverable:

Locally collected data gathered, organized, stored, and documented

Est. start date: 7/1/2014

Est. end date: 6/30/2015

ID	Task Description	Person Days
1.4	**Gather locally collected data**	**35**
a)	Identify data collected by stakeholders and local governments	1
b)	Contact agencies that collect data and arrange for transfer	10
c)	Organize storage for data	2
d)	Load data collected into storage	20
e)	Prepare/update documentation	2

2 Model inputs

2.1 *Maintain and update networks, and zonal data*

Maintain and update highway and transit networks, and zonal data whenever new data (such as school enrollment or zonal path density and average block size) are available, new attributes (such as on-street parking, truck prohibited links and lanes indicator) are needed in the model, new projects are completed, or errors are discovered. A new 2013 base year network and SE data will be created as well.

2.1.1 Develop a tool to facilitate external review of highway and transit networks

Highway and transit networks ideally should be reviewed by local planning staff and be updated annually. This task will develop a tool to make TRM networks with attributes available to local planning staff for review and comment perhaps similarly to the employment geo-coder tool. The task includes specifying the review to be done by the planners, designing a way to accomplish the review, and implementing the design. The task also includes developing instructions for performing the review of highway and transit networks.

Deliverable:

Working tool and documentation for tool developed

Est. start date: 1/5/2015

Est. end date: 3/12/2015

ID	Task Description	Person Days
2.1.1	**Develop a tool to facilitate external review of highway and transit networks**	**20**
a)	Specify review to be done by local planners	2
b)	Design an approach to accomplish the review specified in a) above	2
c)	Implement the approach designed in b) above including testing & debugging	10
d)	Document tool developed & prepare instructions for use/delivery	6

2.1.2 Develop 2013 base year highway and transit network and SE data

The region has determined that in order to have a new base year for developing the next Metropolitan Transportation Plan (MTP), a base year of 2013 will need to be developed. This task will use information provided by the stakeholders to prepare and check highway and transit networks for 2013. New SE data tables for 2013 will be developed. These model inputs will be tested to make sure they work in the TRM v6 model, and the model results will be compared to model validation targets.

Deliverables:

2013 TRM v6 highway and transit networks and SE data

2013 base year networks and SE data table

2013 base validation report

Est. start date: 7/1/2014

Est. end date: 12/24/2014

ID	Task Description	Person Days
2.1.2	**Develop 2013 base year highway and transit network and SE data**	**127**
a)	Gather from stakeholders all needed information	3
b)	Enter new transit system data and any service changes in 2013	15
c)	Prepare new SE data table for 2013 and any derived variables including employment by type and earnings and synthesize 2013 population	25
d)	Test 2013 highway and transit networks and SE data in TRM v6	2
e)	Check modeled bus speeds against observed	5
f)	Prepare average weekday fares from system data provided by stakeholders	10
g)	Prepare summary of transit riders by company for validation	2
h)	Prepare traffic count summaries for peak hour and period and vehicle type by direction and associate with network links, screen lines and cut lines	20
i)	Run 2013 model and compare results to validation traffic counts and transit passenger counts including screen lines and cut lines	10
j)	Address any issues identified in the validation comparisons	30
k)	Prepare documentation for the 2013 model including validation report	5

2.1.3 Conduct review of highway network

Review took place during FY 2014 and placeholder for future work

2.1.4 Create the True Universe Network for TRMv6

The true universe network for TRMv6 needs to be created for conducting analysis during the development of the 2045 MTP. This network will take the updated 2010 highway network as the base year network, incorporate the projects between 2010 and 2013, and incorporate the future year projects coded in the TRMv5 true universe network. Stakeholders need to code their own projects on this TRMv6 true universe network for the 2045 MTP analysis.

Deliverable:

The TRMv6 true universe network

Est. start date: 7/1/2014

Est. end date: 9/5/2014

ID	Task Description	Person Days
2.1.4	**Create the True Universe Network for TRMv6**	**49**
a)	Replace the base year network as the new TRMv6 2010 network	2
b)	Code the projects between 2010 and 2013	10
c)	Incorporate the future year projects from the TRMv5 true universe network (including incorporating new links and new attributes)	20
d)	Clean and check the TRMv6 true universe network (check for connectivity, centroid connectors, transit only links, etc.)	15
e)	Prepare tech memo documenting preparation of the True Universe Network for TRMv6	2

2.1.5 Develop network coding manual and procedures including QA/QC

A network coding manual will be developed to describe how to represent existing and future highway and transit facilities. This will supplement the User's Guide by providing guidance for handling specific situations and where possible examples will be provided.

Deliverable:

Network coding manual document that can be distributed with model files

Est. start date: 1/7/2015

Est. end date: 2/26/2015

ID	Task Description	Person Days
2.1.5	**Develop network coding manual and procedures including QA/QC**	**16**
a)	Develop draft network coding manual for team review	8
b)	Team review of network coding manual including suggested additions	6
c)	Prepare network coding manual for distribution	2

2.2 *Enhance Net Manager to work with v6 model networks*

Work performed during FY 2014 focused on making Net Manager work with TRM v6. The tool therefore has been updated based on the data attributes and logic in and between the attributes. However, without a TRMv6 True Universe network, the tool has not yet been tested on a TRMv6 True Universe network, so some testing and debugging work is anticipated during

FY 2015.

a) Test and debug the Net Manager tool for the TRMv6 True Universe network

b) Provide Net Manager-related technical support to the stakeholder agencies

Deliverable:

Enhanced Net Manager script tested and debugged with TRMv6 True Universe network.

Est. start date: 2/2/2015

Est. end date: 3/15/2015

ID	Task Description	Person Days
2.2	**Enhance Net Manager to work with v6 model networks**	**15**
a)	Test and debug the Net Manager tool for TRMv6 True Universe network	5
b)	Provide Net Manager-related technical support to the stakeholder agencies	10

2.3 *Zone geography*

Objectives:

To make script and inputs work with new TAZ geography for TRM v6

Previous work:

TAZ geography was updated by the MPO partners during FY 2012. This included modifications to the highway network to make it consistent with the updated TAZ geography.

2.3.1 Script and input file modifications

Task completed during FY 2013.

2.3.2 Review district definitions

This task will perform a review of the district definitions using the TRN v6 TAZ geography and will make any needed adjustments to accommodate the revised TAZs.

Task was completed during FY 2014

2.4 *Develop highway network procedures*

These tasks were completed during FY 13 and no further work is proposed during FY 15.

2.5 *Transit networks*

2.5.1 Develop improved transit model procedures

Task completed during FY 2013.

2.5.2 Develop transit select link analysis tool

It has been suggested that a tool be created to allow users to perform select link analysis on transit model output (a postprocessor). While tools to perform this analysis are available in TransCAD, it is desired to make the process available directly from the TRM user interface, and to make it easier to use by scripting it.

Placeholder for future work

2.6 Zonal data & models

2.6.1 Population synthesizer

Task completed during FY 2013

2.6.2 Employment synthesizer: investigation of employee type at place of work

Task completed during FY 2013

2.6.3 Employment synthesizer

Work on this task took place during FY 2013 and FY 2014. An approach was developed and a prototype was tested to link Community Viz information with future forecasts, but work is still needed to develop a set of tools and instructions for creating employment by type and earnings at the establishment end during the creation of forecasts.

2.6.3.7 Employment synthesizer toolkit

This task will create tools to create inputs needed by the TRMv6 model when preparing forecasts.

Deliverable:

Set of tools with instructions (User's Guide) for preparing forecasts of employment by type and earning using Community Viz information.

Est. start date: 3/4/2014

Est. end date: 5/7/2014

ID	Task Description	Person Days
2.6.3.7	**Employment synthesizer toolkit**	**20**
a)	Design toolkit to convert CommunityViz forecast allocation output to TRM employment by type and earning	5
b)	Develop set of tools "toolkit" to convert CommunityViz output to TRM inputs	10
c)	Prepare User's Guide for toolkit	5

2.6.4 Long-term decision models

It is possible to distinguish between decisions people make at long intervals (new home location, new employment location, school location, auto purchase), and decisions that are made at short intervals or even every day (shopping, recreation). Models of the decisions made at long intervals are developed early in model development, so later models can be conditional on the long interval decisions. The auto ownership model is proposed to be prepared first.

2.6.4.1 Auto ownership model

Auto ownership plays a role in travel choices throughout the TRM. An important difference between aggregate trip based models and activity-based models is that in trip based models the auto ownership model usually comes before trip generation, whereas with activity-based models it usually comes after the models of usual workplace, and school locations. This reflects that if the work location is farther away, a household is more likely to purchase more cars (both for the worker(s) and for other non-worker(s). For the approach to add new components to the trip based model, it may make sense to develop an auto ownership model before trip generation, but it is very likely that it will be re-estimated for a later tour or activity-based model.

2.6.4.1.1 Investigation

The investigation of auto ownership models was completed during FY 13

2.6.4.1.2 Estimation of an Auto Ownership Model for TRM v7

An auto ownership model is recommended for TRM v7. This task will specify an auto ownership model, prepare data for estimating an auto ownership model using the 2006 household survey data, and estimate the specified auto ownership model.

Placeholder for future work

2.6.4.2 Usual workplace location model

In tour based and activity based models the workplace location is a key anchor for workers along with the home location that determines how other activities may be planned throughout the day. It also helps determine if other stops will be made on the trip to and from work. This task will develop a usual workplace location model as part of TRMv7.

2.6.4.2.1 Investigation

Work on the usual workplace location model will begin with a review of approaches that have been used by other metropolitan areas. Criteria to select an appropriate usual workplace location model for the TRM will be developed and a technical memorandum will be prepared to enable the Model Team to make a recommendation of the model form to develop for application in the TRM.

Deliverable:

Technical memorandum

Est. start date: 4/1/2015

Est. end date: 4/14/2015

ID	Task Description	Person Days
2.6.4.2.1	**Investigation**	**10**
a)	Review usual workplace location modeling approaches	5
b)	Document findings in draft technical memorandum	3
c)	Revise technical memorandum	2

2.6.4.3 Usual school location model

For school children the usual school location plays a similar role to that of the workplace location for workers in that the school location is an anchor for planning other activities. The school location will also help explain whether a worker drops off a child at school on the way to work, or if a non-working member of the household drops off the child at school. In the latter case the school location becomes an anchor for a school based tour for the non-working member of the household. This task will develop a model of usual school location for school age children including forecasting future school locations for TRMv7.

2.6.4.3.1 Investigation

Work on the usual school location model will begin with a review of approaches that have been used by other metropolitan areas. Criteria to select an appropriate usual school location model for the TRM will be developed and a technical memorandum will be prepared to enable the Model Team to make a recommendation of the model form to develop for application in the TRM.

Deliverable:

Technical memorandum

Est. start date: 4/15/2015

Est. end date: 4/28/2015

ID	Task Description	Person Days
2.6.4.3.1	**Investigation**	**10**
a)	Review usual school location modeling approaches	5
b)	Document findings in draft technical memorandum	3
c)	Revise technical memorandum	2

2.7 *Develop an improved parking constraint model*

Purpose: Improve parking constraint model to better address regional policy issues with sub-area analysis within a PASA.

Objective: Finalize improved parking cost and capacity constraint model specifications; review parking analysis sub-area (PASA); design parking behavior data collection plan and instrument; collect, process and analyze data; prepare parking behavior data for model development; collect, process and analyze parking inventory data (facility location, capacity by use type, parking rate, and usage); prepare parking inventory data for model development; and develop and implement improved parking constraint models in TRM v6. If possible and appropriate data is available, a TAZ level model will be developed for application.

Previous work:

In FY 2012 TRM SB staff reviewed and evaluated other region's parking constraint model practice and associated parking data collection approach. In FY 2013 the Model Team approved the initial design of new parking constraint models for TRM v6.

FY 2015 main tasks:

1) Review and revise parking analysis sub-area (PASA) (completed FY 2014)
2) Collect and review parking model related data for 2013 including inventory of parking facilities/pricing/occupancy rate
3) Prepare parking inventory data for 2013 (facility location, capacity, rate and usage) for model estimation
4) Collect parking behavior data. A survey consultant will be hired by a stakeholder partner to conduct the survey, while TRM SB will provide advice, including pilot and final survey data QA/QC (see task 1.1 above)
5) Process and analyze parking behavior data for model development use
6) Develop improved parking models [estimation, calibration and validation]
7) Implement improved parking models in TRM v6 model stream (updating TransCAD script, FORTRAN program and so on)
8) Document the TRM v6 improved parking model development

Effort estimated for the sub-tasks is based on the assumption that all three of the proposed parking choice models will be developed, while time needed for each model is given separately.

2.7.1 Design TRM v6 parking constraint models

Task completed during FY 2013

2.7.2 Review Parking Analysis Sub-Area (PASA)

Task completed during FY 2014

2.7.3 Collect, process and analyze parking inventory data

Deliverables:

1) Technical memorandum summarizing analysis of parking use data for the general public and university students
2) Technical memorandum summarizing parking capacity data preparation for the general public and university students
3) Parking inventory data ready to use

Est. start date: 7/3/2014

Est. end date: 10/23/2014

ID	Task Description	Person Days
2.7.3	**Collect, process and analyze parking inventory data**	**17**
a)	Analyze & allocate parking capacity between the general public and university students for each PASA	15
e)	Documentation	2

2.7.4 Analyze parking behavior survey data and prepare estimation data

Deliverables:

1) Technical memorandum summarizing parking behavior survey data analysis
2) Technical memorandum on parking behavior survey data process and preparation
3) Model estimation data files ready to use

Est. start date: 10/24/2014

Est. end date: 12/15/2014

ID	Task Description	Person Days
2.7.4	**Analyze parking behavior survey data and prepare estimation data**	**37**
a)	Parking Location Choice Model: Analyze parking behavior survey data (on relations to be used in v6 model estimation)	19
b)	Parking Reserved Space Choice Model: Analyze parking behavior survey data (on relations to be used in v6 estimation)	9
c)	Parking Monetary Subsidy Choice Model: Process and prepare parking behavior survey data (on relations to be used in v6 model estimation)	9

2.7.5 Develop implementation specification in TRM stream

It is anticipated that the model will be applied at the TAZ level if data to support TAZ level application can be developed.

Deliverables:

1) Input files (in addition to the parking behavior data files) ready to use
2) TransCAD script/FORTRAN program and model input/output structure ready to use

Est. start date: 12/16/2014

Est. end date: 1/23/2015

ID	Task Description	Person Days
2.7.5	**Develop implementation specification into TRM stream**	**29**
a)	Parking Location Choice Model	17
b)	Parking Reserved Space Choice Model	6
c)	Parking Monetary Subsidy Choice Model	6

2.7.6 Estimate TRM v6 parking constraint models

Est. start date: 1/26/2015

Est. end date: 3/5/2015

ID	Task Description	Person Days
2.7.6	**Estimate TRM v6 parking constraint model**	**29**
a)	Parking Location Choice Model	17
b)	Parking Reserved Space Choice Model	6
c)	Parking Monetary Subsidy Choice Model	6

2.7.7 Calibrate TRM v6 parking constraint models

Deliverables:

1) Technical memorandum documents v6 parking model estimation and calibration process, with statistical test results; and model performance
2) Calibrated model (parameters, any input files))

Est. start date: 3/6/2015

Est. end date: 4/17/2015

ID	Task Description	Person Days
2.7.7	**Calibrate model**	**31**
a)	Parking Location Choice Model	21
b)	Parking Reserved Space Choice Model	5
c)	Parking Monetary Subsidy Choice Model	5

2.7.8 Validate TRM v6 parking constraint models and final adjustment

Deliverables:

1) Technical memorandum document on TRM v6 parking model validation process
2) Finalized model specification and parameters (and input files)

Est. start date: 4/20/2015

Est. end date: 5/28/2015

ID	Task Description	Person Days
2.7.8	**Validate model and final adjustment**	**29**
a)	Parking Location Choice Model	15
b)	Parking Reserved Space Choice Model	7
c)	Parking Monetary Subsidy Choice Model	7

2.7.9 Final documentation

Deliverables:

1) Technical memorandum on entire Task 2.7 TRM v6 Parking cost/capacity constraint model development
2) Ready to use model components (TransCAD script, FORTRAN program, parameters, model structure, input files)

Est. start date: 5/29/2015

Est. end date: 6/11/2015

ID	Task Description	Person Days
2.7.9	**Final documentation**	**10**

2.8 *Data management systems*

To develop a regional model, large amounts of data of different types need to be used, as has been demonstrated during development of the TRM model. The data include, but are not limited to: network data (highway, transit, bicycle-path, and pedestrian/sidewalks), socio-economic data (census, ACS, CTPP, InfoUSA), travel survey data (household, transit on board, external station, commercial vehicle, college student), traffic OD flow data (CTPP and cell phone location), traffic count, speed, and travel time data (NCDOT, INRIX, Traffic.com), and so forth. It is expected that more efficient and effective use can be made of the data if it is organized into an integrated data management system. It is also expected that more advanced models will require new approaches to storing and processing data. For example, disaggregate or person based models process lists of related data instead of matrices of zone based data. All these suggest that design of an integrated data system should be undertaken, especially in the early stage of development of the new model. Since an incremental approach to developing the new model is proposed, it will also be good to consider how components developed as additions to the trip based model will be modified to work in a new model system.

2.8.1 Investigation

An investigation will be made of the ways that regions have organized data storage and systems for advanced models. Tools for managing large databases or data files will be investigated. This task will consider the choice of an appropriate data management system and appropriate programming language(s) for the application development. Particular attention will be paid to the tradeoff between borrowing tools developed for application in other regions versus the effort needed to program new application procedures. This task will also recommend the expertise needed for system design and programming. Collaboration with computer science students and professors will be sought for this task with a view toward building an arrangement to carry through to the end of the project to develop the new model. A summary of findings will be provided in a technical memorandum.

Deliverable:

Technical memorandum

Est. start date: 5/4/2015

Est. end date: 6/30/2015

ID	Task Description	Person Days
2.8.1	**Investigation of data systems**	**40**
a)	Review existing approaches to organize and store data systems for advanced models	10
b)	Investigate tools for managing large databases	20
c)	Efforts to establish collaboration with computer science	5
d)	Prepare a summary of investigation findings in technical memorandum	5
e)	Conduct and document requirements analysis and (if time allows) database system design (30 days for this task deferred to FY 2016)	0

3 Trip generation

3.1 *Re-estimation and/or re-calibration of trip production models*

Task completed during FY 2014

4 Time of day and peak spreading model

The current TRM v5 model uses fixed time-of-day factors to slice a daily trip matrix into multiple time periods of a day and estimates traffic conditions for each time period by assigning the

sliced trip matrices onto the highway network. This is a typical time-of-day modeling approach widely used in the US. However, since time-of-day factors are most commonly specified as exogenous values derived from the household survey data or traffic count data, they are fixed and independent of congestion levels. Even when congestion gets more severe, the model still assumes the percentage of travelers that start their trips in the peak period will keep unchanged, which is not realistic and can over estimate traffic congestion for the peak period. It has been observed from travel surveys that the peak spreads when congestion gets more severe. A more sophisticated congestion-level-dependent time-of-day (or called peak spreading) modeling method should be employed in the TRM to better simulate traffic conditions.

4.1 *Peak spreading model*

Task completed during FY 2014

4.2 *Prepare time of day factors*

Task completed during FY 2014

5 Trip distribution

5.1 *Develop improved destination choice model*

Objective:

The purpose of this task is to improve the TRM v5 destination choice model. The objective is for v6 to better model trip distribution for each trip purpose by household strata, by employee type (including employer business type and employee earning levels for HBW, and business type for other trip purposes); focusing more on individual person types; to improve the accuracy of trip attraction allocation by purpose to appropriate destinations for each of the five household strata and/or employee types used in TRM v6. This task will include finalizing a model specification.

In FY 2013:

Stakeholders reviewed and approved the TRM SB initial design specification for the improved destination choice models.

FY 2014 main tasks:

1) Identify sources of model estimation data
2) Script modifications to include destination choice model in TRM v6 model stream, including creating input/control files for model parameters (replacing the existing hard-coded coefficients in the FORTRAN program)
3) Possibly replacing the current FORTRAN program with TransCAD GISDK script
4) Prepare model estimation file from re-expanded/weighted 2006 Household Travel Survey and other data sources (e.g., traffic skims, and SESyn output of employment types for HBW, and other trip purposes respectively)
5) Finalize model specification
6) Develop improved destination choice model (estimation, calibration and validation)
7) Document the model development process

Final product will be a technical memorandum that documents the entire process above, model performance; and a completely updated ready-to-use destination choice model (including TransCAD scripts, FORTRAN programs, input data files and finalized parameters).

5.1.1 Review TRM v5 destination choice – attraction share model

Task completed during FY 2013.

5.1.2 Design TRM v6 destination choice model specifications

Task completed during FY 2013.

5.1.3 Script modifications for application of destination choice in TRM v6

Task completed during FY 2014

5.1.4 Prepare v6 destination choice model estimation files

This set of tasks will include developing and estimating new attraction share models that will be used to develop weights to be used during destination choice sampling of TAZs (sub-task b below).

Task completed during FY 2014

5.1.5 Estimate model using new specification

Task completed during FY 2014

5.1.6 Calibrate model

Task completed during FY 2014

5.1.7 Validate model

Task completed during FY 2014

5.1.8 Final adjustment

Task completed during FY 2014

5.1.9 Documentation

Task completed during FY 2014

6 Non-motorized

6.1 *Estimation and calibration of non-motorized models*

a) Adjust the non-motorized model script to fit the TRMv6 TAZ system.

This sub-task includes:

- Compare new time-of-day factors to those used in TRM v5 and document the difference
- Prepare non-motorized model specific zonal input data such as average block length, non-motorized path density with new zonal data
- Run initial non-motorized models with the newly developed time-of-day factors and zonal data
- Prepare the observed non-motorized target data from re-expanded/weighted household survey data
- Evaluate model results versus the observed target
- Determine whether the models need to be re-estimated and re-calibrated

If they do, then:

b) Prepare the model estimation files, which includes calculating household characteristics, TAZ attributes, and inter-TAZ travel impedance
c) Re-estimate and calibrate for non-motorized models by time period and strata
d) Implement re-calibrated non-motorized model in model stream (updating model script and parameter files
e) Document the work on re-estimation and re-calibration of Non-motorized Models including calibration results.

Task completed during FY 2014

7 Mode choice

7.1 *Re-calibration of mode choice models*

a) Adjust the mode choice model script and FORTRAN program and control files to fit the TRMv6 TAZ system
b) Prepare the mode choice calibration targets from the re-expanded/weighted 2006 Household Survey and 2006 Transit On-board Survey
c) Investigate mode choice estimation and make recommendation to team
d) If feasible and recommended, estimate mode choice models
e) Re-calibrate Mode Choice Model alternative specific constants
f) Implement re-calibrated mode choice models in model stream by updating TransCAD script, FORTRAN program and control files when necessary
g) Document the work on calibration of Mode Choice Models.

Task completed during FY 2014

8 Special models

8.1 *Develop an improved commercial vehicle model (CVM)*

The following sub-sections detail the steps and related tasks required to complete the CVM and in particular to prepare it for use with v6 model inputs.

8.1.1 Model estimation and calibration with v6 input data

a) Trip generation model:

1) Investigate and improve CV trip generation model for TRM v6

2) Update model script and documentation

b) Trip distribution model:

1) Generate new highway travel time and travel distance skim matrices from TRM v6. Both AM peak and PM peak travel times are needed to distribute the trips by time of day.

2) Update model estimation datasets

3) Re-estimate destination choice models based on new SE data and new skim data

4) Derive new trip length frequency distributions based on the improved TAZs and new highway travel times

5) Calibrate destination choice models to align model estimated average trip lengths with observed trip lengths

6) Update the GISDK macro to implement destination choice model in v6

Task completed during FY 2014

8.1.2 Interfacing with NC Statewide Model for CV IE-EI and E-E Trips

a) Develop a correspondence between NCSTM and TRM zones and between NCSTM and TRM employment types

The NCSTM created its zone structure for the Triangle Region based on the TRM v5 zones. Since the new v6 zones are a bit different from those in TRM v5, a more complicated correspondence table will need to be developed between the NCSTM zones and the TRM v6 zones.

The correspondence table will contain estimated percentages to allocate population, households, and employment by type in each of the NCSTM zones to TRM zones that have been geographically over laid. Since NCSTM uses a different employment categorization scheme from the TRM, conciliation between the schemes is anticipated using another correspondence table.

b) Conduct sub-area analysis using NCSTM

A subarea analysis will need to be conducted in NCSTM to identify the pairs of ODs that have trips passing through TRM external stations and produce initial I-E/E-I and E-E trip tables. It will be necessary to get familiar with the NCSTM and to set up the model correctly on a local computer before conducting the sub-area analysis.

c) Allocate internal trip ends to TRM internal zones

With allocated socioeconomic data, the internal trip ends of I-E and E-I trips will need to be allocated from the NCSTM to the TRM. Since NCSTM and TRM have different trip generation models and employment classifications, reconciliation between the two models is anticipated in order to successfully integrate them. Comparison between model estimates using the two models along with some adjustments may be needed to find the best solution for internal trip end allocation. Further adjustments are anticipated in the model validation stage where modeled VMT or volumes are compared with observed VMT or counts in the region.

d) Allocate external trip ends to TRM external stations

Allocating external trip ends (relative to the TRM model boundary) reasonably to TRM external stations is critical. However, unlike the TRM, many of the local roads and even some collectors are not included in the NCSTM making this task a bit challenging. Based on the results from step b), certain percentages of trips will have to be assumed and be allocated from the major roads to adjacent roads that are present in the TRM but not in the NCSTM. Both I-E/E-I and E-E trips will need to be included in the analysis.

e) Adjust disaggregated NCSTM estimates to align estimated volumes with counts at external stations

Truck trip ends (or called traffic volumes) at each TRM external station as estimated in the previous step will be compared with actual ground truck counts for the base year. One ratio will be developed and be applied where necessary as a factor to align the estimated volumes with the counts at each external station. The other end of those impacted trips will be factored too, to remain consistent.

f) Re-balance disaggregated E-E trip tables

After disaggregation and factoring, it is necessary to re-balance the disaggregated E-E trip tables so that at each external station the numbers of inbound and outbound trips are close (ideally equal) and the to and from flows between any pair of external stations are close (ideally equal).

g) Implement the interfacing approach in GISDK and integrate it with the other parts of the model

Task completed during FY 2014

8.1.3 Develop truck-prohibited link and lane function in v6

a) Identify the truck-prohibited links and lanes in v6 highway network

b) Implement truck-prohibited links and lanes in TRM v6. It is anticipated that script modifications will be made at many places in the v6 model because change of network is a fundamental change and impacts anywhere the network is used in the model, such as the steps of Create Network, Trip Distribution, and Highway Assignment. Full testing of the entire model is needed to make sure all the pieces impacted still work correctly.

Task completed during FY 2014

8.1.4 Script modifications for time of day traffic assignment

a) Implement time-of-day CV traffic assignment in v6. Since the v6 model is going to implement 4 time periods of day, additional scripting will be needed.

Task completed during FY 2014

8.1.5 Validate model using 2010 classification traffic counts and VMT data

a) Develop validation data including classification counts and VMT data

b) Compare model performance to validation data and adjust the model to improve its performance

Task completed during FY 2014

8.1.6 Update overall model documentation for commercial vehicle model

a) Model documentation prepared in FY 2012 based on the v5 data will be updated fully to reflect the modeling efforts made and results achieved using the v6 data.

Task completed during FY 2014

8.2 University student model

The TRMv5 included university students with other adults as workers and non-workers with and without autos. Trips from home to the three main campuses were modeled as a separate trip purpose (Home Based University or HBU). While this approach improved on earlier models, it left room for improvement, in particular for non-home based travel between Duke University east and west campuses and NCSU main and Centennial campuses. An improved university student model will be developed to better represent travel choices made by students.

8.2.1 Investigation of university student models

Task completed during FY 2013.

8.2.2 Prepare available university student data for analysis

Task completed during FY 2013.

8.2.3 Trip/activity generation model estimation

Task completed during FY 2013.

8.2.4 Destination choice model estimation

Task completed during FY 2013.

8.2.5 Non-motorized model estimation

The current TRM v5 model includes a step to separate trips into non-motorized and motorized modes after destination choice. If this structure is recommended for the university student model, then non-motorized models will be estimated for trips or tours/stops on tours.

a) Develop model estimation files based on the 2001 NCSU student survey

b) Re-estimate non-motorized models by 4 trip purposes, 2 time periods and 2 strata (on-campus and off-campus students)

c) Documentation

Task completed during FY 2014

8.2.6 Prepare models for application

It is anticipated that the university student models will require new model scripts to be written. This is expected to be a substantial effort that will include the design of inputs and outputs, script flow, coding, and execution testing. Due to the special model structures of the student models (e.g., the trip purposes are different), the script for the general public may not be easily adapted for the university students.

a) Prepare the destination choice model script to implement the university student destination choice model

b) Prepare the non-motorized model script to implement the university student non-motorized model

c) Prepare the mode choice model script to implement the university student mode choice model.

Task completed during FY 2014

8.2.7 Calibration of the university destination choice model

The university trip distribution model needs to be calibrated to match the average trip length and the trip length distribution observed from the 2001 NCSU survey.

a) Prepare calibration target data from the 2001 NCSU student survey

b) Calibrate the model

c) Document calibration process.

Task completed during FY 2014

8.2.8 Calibration of the university non-motorized model

The university non-motorized model needs to be calibrated to match the share of the non-motorized trips observed from the 2001 NCSU survey.

a) Prepare calibration target data from the 2001 NCSU student survey

b) Calibrate the model

c) Document calibration process

Task completed during FY 2014

8.2.9 Calibration of the university mode choice model

Mode choice models will be estimated for university student trips. University students account for 61% of the transit trips and 57% of the transit ridership in the Triangle area. It is important to make sure the mode choice models for the general public (5 household strata) and for the university students are consistent so that the total number of transit trips meet the target.

a) Prepare the calibration targets from the 2001 NCSU student survey and the 2006 transit on-board survey

b) Calibrate the model

c) Document calibration process

Task completed during FY 2014

8.2.10 Model validation and final documentation

Validation data will be prepared depending on availability. The university student models will be validated and documented

Task completed during FY 2014

8.2.11 Add university student trips to general public trips

This task will make all needed modifications to the model script to incorporate the university student trips in the trips to be assigned for highways and transit.

Deliverable:

Updated model script and other edits with brief description of changes made

Est. start date: 7/1/2014

Est. end date: 12/31/2014

ID	Task Description	Person Days
8.2.11	**Add university student trips to general public trips**	**10**
a)	Make any needed script revisions for TRM v6 to add university student trips to all other trips for trip assignment including testing	9
b)	Documentation for all script revisions	1

8.3 *Land use models*

Other regions have included the integration of a regional land use model with their advanced travel demand models. The Triangle region has experience with the UrbanSim land use model. It is suggested that the region consider whether to integrate a land use model with the TRM.

8.3.1 Investigation

Task completed during FY 2013

8.4 *Update external travel models (I-E, E-I, and EE)*

External travel models need to be updated for TRM v6 to accommodate changes in TAZs.

8.4.1 Update external travel models

New work will include scripting the external transit trip inputs. This task will also include an investigation of using alternative sources of external travel data to augment the information

provided by the NC Statewide Model. Specifically, data will be sought to provide information for lower level facilities not included in the NC Statewide Model.

Deliverable:

Updated model inputs for external travel models, script for preparing external transit trip tables and documentation for all updates

Est. start date: 1/5/2015

Est. end date: 2/4/2015

ID	Task Description	Person Days
8.4.1	**Update external travel models**	**23**
a)	Make any needed script revisions for TRM v6	1
b)	Update input files as needed for external travel	2
c)	Investigation of alternate sources of external travel data	5
d)	Develop script to automate creation of transit external trip table and test it	10
e)	Documentation for all updates & results of investigation	5

8.5 *Links to MOVES air quality models*

MOVES is now required for performing air quality analysis for long range transportation plan conformity determinations. It is desired to create procedures within the TRM to prepare output data for MOVES analysis. This task will identify the best approach to integrate MOVES analysis in the TRM and prepare scripting to implement it.

8.5.1 Develop module to link MOVES air quality models with TRM

A module will be designed based on approaches used by other regions to link MOVES air quality models with aggregate trip based models. This work will be coordinated with air quality staff at the NC Dept. of Environment and Natural Resources, and NCDOT.

Deliverable:

A working module to prepare TRM output for MOVES analysis. Documentation of module developed.

Est. start date: 4/22/2015

Est. end date: 6/30/2015

ID	Task Description	Person Days
8.5.1	**Develop module to link MOVES air quality models with TRM**	**22**
a)	Obtain information on and review approaches used in other regions to link model output to MOVES	5
b)	Design module to prepare MOVES model inputs from TRM output	2
c)	Implement module designed in b) above, and test	12
d)	Document module created in c) above	3

8.6 *Sub-area and corridor analysis procedures*

When applying a regional model to a sub-area or corridor level of analysis, special procedures are needed. This task will investigate approaches used in other regions and recommend an approach to apply to the TRM. Depending on the approach that is recommended, subsequent tasks will design and implement the recommended procedure in the TRM.

8.6.1 Procedures for performing sub-area and corridor analysis - investigation

Procedures for performing sub-area and corridor analyses will be investigated. Practice at other MPOs will be described. A recommendation will be made for procedures to implement in the TRM.

Deliverable:

A technical memorandum describing procedures used at MPOs elsewhere and a recommendation for procedures to implement in the TRM

Est. start date: 4/1/2015

Est. end date: 4/15/2015

ID	Task Description	Person Days
8.6.1	**Procedures for performing sub-area and corridor analyses - investigation**	**5**
a)	Obtain information on approaches used in other regions to perform sub-area and corridor level analyses using aggregate trip based models	3
b)	Prepare technical memorandum summarizing findings and recommendation	2

8.6.2 Prepare set of procedures for performing sub-area and corridor analysis

Based on recommendation made in 8.6.1 above develop/prepare a set of tools and scripts to implement the recommended approach. A set of instructions will be developed for users.

Deliverable:

A set of tools and/or scripts along with a set of instructions

Est. start date: 4/16/2015

Est. end date: 6/30/2015

ID	Task Description	Person Days
8.6.2	**Prepare set of procedures for performing sub-area and corridor analyses**	**20**
a)	Design set of tools to perform sub-area and corridor level analyses using the TRM	5
b)	Based on the design in item a), create tools or scripts to implement it, and test them	10
c)	Prepare set of instructions for use of the tools developed in b) above	5

9 Trip assignment, calibration & validation

The v6 model while similar to the v5 model will have many improved components that will affect the results of highway and transit assignment. One major improvement is the new highway network procedure. This new procedure might have a large impact on the highway and transit assignments because, a) intersection delays are considered in the v6 model but not in the v5 model, therefore speeds on interrupted facilities in the v6 model will generally be lower than those in the v5 model; b) the facility types and corresponding free-flow speeds and capacities used in the v6 model are different from those in the v5 model. It is still unclear how large the impacts are. All the model estimations and calibrations before highway assignments will use the network skims based on the congested speeds from assigning the v5 model output on the v6 network. When the initial highway assignments are completed in the v6 model, it might be necessary to re-estimate and/or re-calibrate all the previous models.

This task will apply the model with 2010 model inputs and the resulting highway and transit assignments will be compared to calibration targets. Data for observed speeds will be compared to model speeds. Comparisons will be made for peak periods as well as for the whole day.

9.1 *Investigate improving highway assignment*

9.1.1 Dynamic traffic assignment

Dynamic traffic assignment is being considered for both pricing and safety planning applications, and tools are being developed that may be appropriate for application in the Triangle region. These include DTALite being developed under an FHWA research project, and the SHRP 2 C10 project combining an activity based model with Dynus T.

An investigation of dynamic traffic assignment was conducted during FY 2013. This task remains as a placeholder for possible future work with dynamic traffic assignment in the TRM.

Timetable:

FY 2016: Select a DTA platform and prepare network and other inputs for a proof of concept

FY 2017: Begin creating a DTA application for TRMv7 using TRM inputs including post processors for new data formats as well as any new input data needed for DTA

9.2 *V6 model assignment and overall model calibration*

9.2.1 Highway assignment

a) Review screen line and cut line definitions for TRM v6 and make any needed corrections
b) Perform assignment and perform reasonableness checks including: centroid connectors with zero volumes, highway links with zero volumes, highway links with speed less than five and ten miles per hour
c) Identify and make any needed model improvements in order to improve assignment such as connecting unconnected links, adding links if missing, and correcting any errors in attribute coding.

Est. start date: 7/1/2014

Est. end date: 7/18/2014

ID	Task Description	Person Days
9.2.1	**Highway assignment**	**13**
a)	Review screen line and cut line definitions in TRM v6	3
b)	Perform assignment and apply reasonableness checks	5
c)	Identify and make any needed model improvements	5

9.2.2 Transit assignment

a) Apply model script for transit assignment and confirm that script works correctly, and if not make corrections

b) Perform assignment and perform reasonableness checks including: transit lines with zero volumes, low transfer rates at downtown transfer stations

c) Identify and make any needed model improvements in order to improve assignment

Est. start date: 7/21/2014

Est. end date: 8/8/2014

ID	Task Description	Person Days
9.2.2	**Transit assignment**	**15**
a)	Apply model script for transit assignment	5
b)	Perform assignment and apply reasonableness checks	5
c)	Identify and make any needed model improvements	5

9.2.3 Model chain calibration/validation

a) Traffic counts (including hourly and classification counts) from 2010 will be adapted for use with v6 networks during model calibration/validation associating them with network links and screen lines/cut lines. Peak period and peak hour counts will be prepared and these will be associated with network links and screen lines/cut lines. Transit passenger counts by route will be adapted if necessary.

b) Initial calibration – evaluation measures script will be run and model performance will be compared to targets for measures listed in Exhibit A-2. Further checks will be made using hourly traffic counts and classification counts. VMT by county will be compared to NCDOT estimates or other sources. Summaries will be generated by region, county and district as appropriate. Additional checks will be made against district to district transit flows in the on-board survey, and extreme high and low highway link assignment differences will be compared to traffic counts. Hourly traffic counts will be compared to AM and PM peak period assignments. Validation checks will be made for a level of facility that will support sub-area and corridor studies.

c) If problems are discovered, model output and procedures will be studied to determine the cause(s) of the problem.

d) A set of adjustments will be designed to address the cause(s) of any problems that are discovered.
e) After adjustments have been made, the model will be run again, and model components (trip generation, trip distribution, mode choice, trip assignment) will be checked against calibration targets by trip purpose.
f) As necessary, model components will be re-calibrated, and the model will be run through again to determine if model performance matches performance targets. This process will be iterated until all problems identified have been addressed and the model meets performance targets.
g) This process of model testing and adjustment will be iterated until the overall model meets calibration and validation targets.
h) Sensitivity tests will be performed with inputs developed for the recently adopted 2040 Metropolitan Transportation Plan converted for application with TRMv6. Model results will be checked for reasonableness and any problems discovered will be documented and addressed.
i) A technical memorandum will be written to document model performance testing and all adjustments made to the model during the process of calibration and validation, including adjustments that are made to components already calibrated during model estimation steps (trip generation, trip distribution, non-motorized, and mode choice) completed earlier.

Deliverables:

Highway assignment completed and calibrated

Transit assignment completed and calibrated

Model stream with feedback completed and calibrated/validated

Technical Memorandum on Highway and Transit assignments and model calibration/validation

Est. start date: 8/11/2014

Est. end date: 12/11/2014

ID	Task Description	Person Days
9.2.3	**Model chain calibration/validation**	**150**
a)	Traffic counts adapted to work with v6 screen lines and cut lines including by time of day/direction and by vehicle class as available	20
b)	Initial calibration summaries prepared and detailed review of results performed including thematic plots and review of outliers and network speeds	20
c)	If problems are found, diagnose cause of problems	20
d)	Design adjustments to address problems	20
e)	Calibration checks made after adjustments	10
f)	If adjustments are made, model components checked for calibration	10
g)	Iterate until overall model meets calibration and validation targets	20
h)	Perform sensitivity tests	10
i)	Technical memorandum prepared documenting calibration/validation	20

Highway calibration might include, but not be limited to, the following work:

a) Focus on the screen lines and cut lines that miss the calibration targets, diagnose and address the issues. The possible approaches are: relocate the centroid connectors, check if the facility type designation is reasonable.

b) Re-estimate and/or re-calibrate the destination choice models, non-motorized models, and mode choice models with the updated network skim.

c) Check the modeled speed and observed speed.

Transit calibration might include, but not be limited to, the following work:

a) Check the transit coding to make sure no coding errors are involved.

b) Check the posted speed on the transit only links.

c) Compare the modeled ridership to the observed ridership by corridor, and identify the corridors that have big discrepancies. Study these corridors to diagnose the cause of problems.

d) Compare the modeled ridership to the observed ridership by route. Any low volume transit routes that do not assign within fifty percent of observed riders and any high volume transit routes that do not assign within thirty percent will be corrected or explained.

e) Check the bus speed, and adjust the bus speed equations when necessary.

f) Check the number of riders at major park and ride lots, and address the issues when found.

g) Apply the improved approach to calculate waiting time when necessary.

f) Re-calibrate the mode choice models when needed.

10 TRM Documentation

As a large, complex model system, the TRM needs to be well documented so it can be understood and be used effectively by stakeholders and others.

10.1 *TRMv6 Documentation*

Documentation will be prepared describing all elements of TRMv6 including data used for model development, estimated and calibrated coefficients, and model performance.

Deliverables:

1. Technical report compilation of technical memoranda
2. TRMv6 model report for a more general audience
3. Updated User's Guide for TRMv6

Est. start date: 1/2/2015

Est. end date: 6/30/2015

ID	Task Description	Person Days
10.1	**TRMv6 Documentation**	**30**
a)	Prepare draft TRMv6 documentation and review by Model Team	30

11 Technical Assistance

11.1 *Assistance with model application for developing the Metropolitan Transportation Plan*

Objective:

To enable stakeholders to prepare alternatives using TRMv6 for MTP analysis

TRM Service Bureau staff will provide assistance for stakeholder partners when they are developing alternatives using the TRM. This will include answering questions and providing assistance when problems arise.

11.2 *Technical assistance with TRM model application on as needed basis*

Objective:

To enable stakeholders (including stakeholder contractors) to apply the model as needed

TRM Service Bureau staff will provide technical assistance for stakeholder partners on an as

needed basis when they are applying the TRM. This will include providing model files and documentation to contractors working on the behalf of stakeholder partners. It will also include answering questions and providing assistance when problems arise.

11.3 *Action items*

Objective:

To address issues identified by stakeholders as Action Items.

From time to time the stakeholders may determine that there are work tasks not covered elsewhere in the work program that nonetheless must be done. During FY2014 such action items were requested by stakeholders. The action item work program element sets aside time for conducting work on tasks as determined by the stakeholders. These tasks will result in a work product, such as a technical memorandum that will document the work done and the completion of the task. Unused time can be allocated to other work tasks after the end of the second quarter.

11.3.1 Addition to TRM of tools developed by stakeholders and others

This task will manage the addition to the TRM of tools developed by stakeholders and others. A workshop type meeting will be held to solicit input including what contractors have found or developed for highways, transit, and the NC Statewide Model. Under this task, the team will decide which tools should be made part of the model interface to be maintained by the Model Team and which will be optional post processors, or not be included at all. Stakeholders and the Model Team will own all the tools to be included in the TRM.

12 Oversight, reporting, and training

Objective:

To enable efficient and effective team communication and project management.

This task includes necessary administrative tasks and meetings needed for project oversight and communication with stakeholders such as Executive Committee, Model Team, and internal TRM Service Bureau meetings. Periodically team members meet both internally and with stakeholders to review task progress and approaches, solve problems, and keep stakeholders informed of work taking place on the project. The project also requires developing an annual work program, task assignments, and monthly team reporting.

12.1 *Oversight & reporting*

12.1.1 Oversight

TRM Team Meetings will be held monthly on the 3rd Thursday of each month unless there are no items to discuss. Model Team members may convene a technical team meeting to review task approaches in detail and develop recommendations for tasks on an as needed basis. Task includes preparation of all presentation materials for meetings.

Executive Committee meetings will be held every other month on Tuesday afternoons, or as designated by executive committee members.

Quarterly progress reports will be prepared in October, January, April, and July. Monthly status

reports will be prepared.

A web site for team collaboration will be maintained to allow the team to share data, analysis, calendar, and documentation to improve collaboration and efficiency.

TRM Service Bureau team members will attend up to a total of four stakeholder project team meetings or one meeting per team member in the course of the project year.

12.2 *Training*

12.2.1 TRM training

Training modules will be developed for stakeholder staff, model users, and consultants. These three groups will be briefly surveyed regarding their needs for training in the use of the TRM. Based on the survey results it is anticipated that three training modules will be developed with each tailored to the needs of each group. Each of the three modules will be given once during the year, and evaluation forms will be distributed to participants. The evaluations will be used to make adjustments to the training modules for future sessions.

ID	Task Description	Person Days
11.2.1	**TRM training**	**7.5**
a)	Review survey of stakeholders, model users, and consultants to determine needed revisions to training modules	1
b)	Revise stakeholder training module	2
c)	Revise model users module	1
d)	Revise consultant module	1
e)	Provide ½ day training for each of three groups	1.5

12.2.2 Staff training

The highly technical nature of the work on the Triangle Regional Model requires that team members update their skills by attending training sessions, using on-line training opportunities, watching Travel Model Improvement Program webinars, and attending model user group meetings. This task will help ensure that up to date skills are applied when performing TRM work.

Appendix A

Vision for Developing the v6 and v7 Models

Policy Testing Needs Identified by Stakeholder Partners

Policy Testing Needs Identified by EC 10/20/2009	Part of Model?
1. Dynamic Tolls	Part of model
2. Greenhouse gas – land use change (Urban Sim)	Part of model
3. Peak spreading (a result)	Part of model
4. Parking constraint in CBD and elsewhere	Part of model
5. Environmental Justice (EJ) impacts (a result)	Analysis done outside model
6. Change mix of land uses within TAZs & consider design of land uses	Part of model
7. TDM policies	Analysis done outside model
8. ITS	Analysis done outside model
9. Making decisions on modal investments	Analysis done outside model

Suggested Elements of New Models or Work Programs

Suggested Elements (FY 2012 list)	In v6	In v7	Invest.	Notes
1. Improved Commercial Vehicle Model	X			DCHC #1
2. Improved Transit Assignment		X		DCHC #2
3a. Static Traffic Assignment Improvements	X		X	DCHC #3
3b. Dynamic Traffic Assignment		X		DCHC #3
4. Area Type Sub-model		X		DCHC #4
5. Population Synthesizer		X		DCHC #5

Suggested Elements (FY 2012 list)	In v6	In v7	Invest.	Notes
6. Trip Attraction and Destination Choice Sub-model	X			DCHC #6
7. University Student Trip Model		X		DCHC #7
8. Walk Access - Transit Link		X		DCHC #8
9. Employment Category and Special Trip Generators		X		DCHC #9
10. System Optimization	X			DCHC #10
11. Time of Day Model		X		DCHC #11
12. Parking Survey and/or Behavior Study		X	X	DCHC #12 Tri. Tran. req.
13a. Link Capacity Calculation			X	DCHC #13 CAMPO req.
13b. Intersection Delay			X	DCHC #13
14. HBW Journey or Tour Based Model		X		
15. Strategic data collection plan			X	MPO req.
16. TAZ review			X	

Suggested Elements (FY 2013 list)	In v6	In v7	Invest.	Notes
1. University student trip model	X			DCHC #1
2. Validation on person and CV trip rate	X			DCHC #2
3. Attraction share and destination choice improvement	X			DCHC #3
4. Mode choice estimation/calibration	X		X	DCHC #4
5. Transit model [updates]	X			DCHC #5
6. Time of day	X			DCHC #6
7. Disaggregated population synthesizer	X			DCHC #7

Suggested Elements (FY 2013 list)	In v6	In v7	Invest.	Notes
8. Auto ownership model	X			DCHC #8
9. Meso-scopic dynamic traffic assignment			X	DCHC #9
10. Action items				CAMPO
12. Parking Survey and/or Behavior Study	X			Tri. Tran.

Suggested Elements (FY 2014 list)	In v6	In v7	Invest.	Notes
1. Transit select link analysis tool	X			CAMPO
2. TRM training for stakeholders, model users, & consultants				CAMPO
3. Attend stakeholder project meetings				CAMPO

Suggested Elements (FY 2015 list)	In v6	In v7	Invest.	Notes
1. Procedure for including tools developed by stakeholders and others in TRM				CAMPO
2. Develop a tool to facilitate review of networks	X			CAMPO

V6 Model

The v6 model will continue to be an aggregate trip based model based on the v5 model. It is expected the v6 model will be used for the 2045 Metropolitan Transportation Plan (MTP) development starting in 2015. The focus for this model will be on further enhancement of the aggregate trip based model.

Fiscal Year	TRM v6 Development	Notes
Year 1 July 1, 2011 - June 30, 2012	Design new commercial vehicle model Optimize model run time performance TAZ modifications Modifications of SE data and SE models Develop improved transit network procedures Investigate and specify enhancements below: 1) definition of facility types 2) link capacity calculation 3) update link free flow speeds 4) intersection delay 5) develop GIS approach to changing future road characteristics 6) improve highway traffic assignment 7) employment categories and special generator definitions 8) investigate and implement improvements to area type calculations	
Year 2 July 1, 2012 - June 30, 2013	Design improved destination choice – attraction share model Develop and implement enhancements below: 1) reviewed & revised employment types for v6, developed and implemented SESyn to estimate population types, HH types, and employee by type at both residence and establishment locations 2) recommended changes to the trip attraction/destination choice sub model using new employment types 3) intersection delay & link capacity calculation implementation including data collection and input 4) designed improved parking constraint models specification and data collection. 5) develop peak spreading model 6) develop university student model Trip generation will be re-estimated using existing survey data.	
Year 3 July 1, 2013 - June 30, 2014	Complete the following enhancements: 1) commercial vehicle model, 2) develop new parking constraint models, 3) develop new university student travel models All remaining model components will be re-estimated using existing survey data. Highway assignment will be QA/QC'd.	[See detailed task list in the scope for more information on individual tasks]
Year 4 July 1, 2014 - June 30, 2015	Model calibration and validation. Work tasks will include calibrating and validating model components and overall model performance. A 2013 base year model will be prepared. Sensitivity tests will be conducted for a forecast year.	

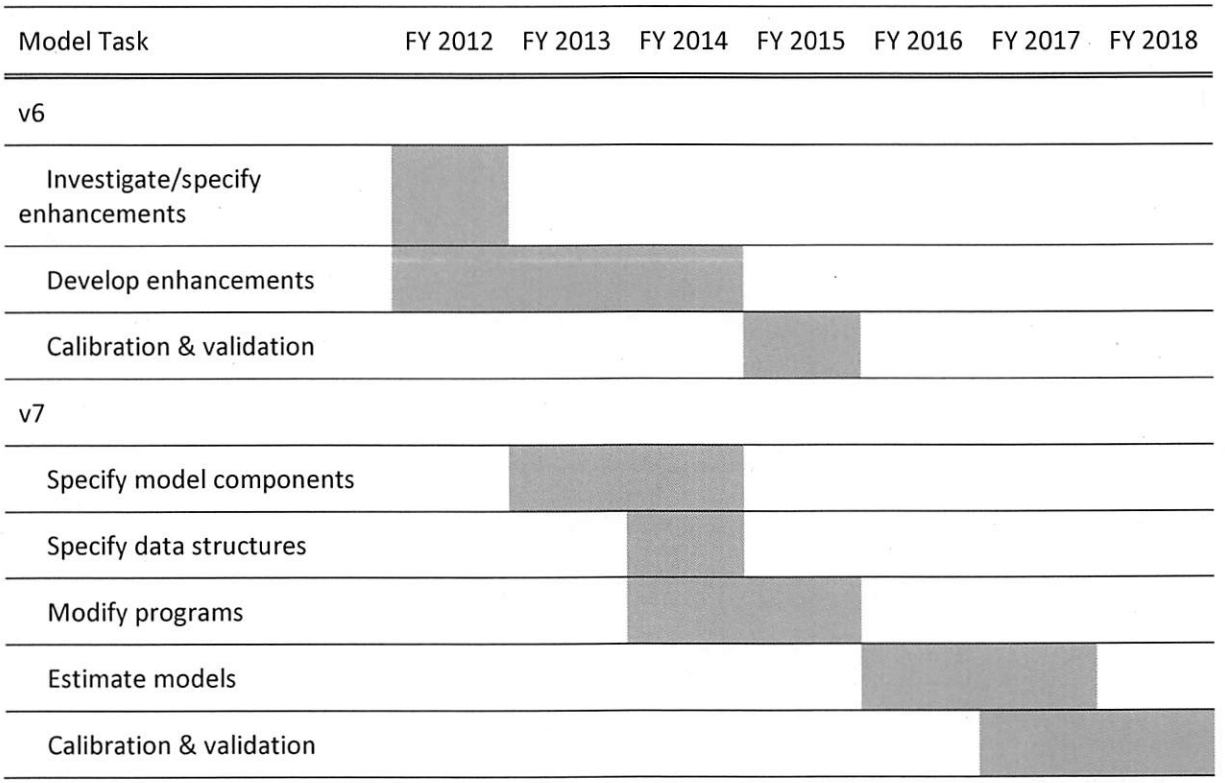
V7 Model

The v7 model will be either a tour based or activity based model depending on stakeholder direction. It is expected the v7 model will be used for 2050 MTP development starting in 2018. This will address policy testing needs that require consideration of how travelers change their daily schedules in response to policies intended to reduce peak congestion.

Fiscal Year	TRM v7 Development	Notes
Year 1 July 1, 2011 - June 30, 2012	Stakeholders agree on concept for v7 1) Convene expert panel 2) Develop work plan for v7 model development	
Year 2 July 1, 2012 - June 30, 2013	Investigation/specification of model structure and components: 1) population synthesizer, 2) land use models. 3) auto ownership model	
Year 3 July 1, 2013 - June 30, 2014		
Year 4 July 1, 2014 - June 30, 2015	Investigation/specification of model structure and components: 1) tour/activity scheduler, 2) router. Investigate/specify and develop data structures. Determine best data structures for storing, processing and updating model elements. Approaches will be sought that maximize analyst productivity and model runtime performance. Available data will be prepared in the chosen data structure.	
Year 5 July 1, 2015 - June 30, 2016	Modify programs as needed to implement the chosen model specification including: 1) population synthesizer, 2) tour/activity scheduler, 3) router. Model component programs may be borrowed and adapted for use in the Triangle region.	

Fiscal Year	TRM v7 Development	Notes
	Estimate models and implement. Recent survey data will be used to estimate model components specified during years one to three [population synthesizer, tour/activity scheduler, router].	
Year 6 July 1, 2016 - June 30, 2017	Continue to estimate models and implement. Recent survey data will be used to estimate model components specified during year one [population synthesizer, tour/activity scheduler, router]. Other model components (commercial vehicles, external models) will be incorporated in overall model structure.	
Year 7 July 1, 2017 - June 30, 2018	Model calibration and validation. Initial model will be applied and any problems will be noted and addressed. This process will be iterated until all problems discovered have been addressed. The model will then be validated to observed conditions.	

Conceptual Schedule for Model Development



Appendix B

TRM History

Version - Release Year [Delivered Time]	Key Features Enhancements vs. Previous Version	Base Year	Use
v.1 - 2006 [Not to Stakeholder]	TTA New Start model converted to the TransCad platform with a 2002 base year as delivered by the contractor [Parsons Brinckerhoff] in Fall of 2006	2002	
v.2- 2006 [delivered 12/2006]	Revised and calibrated/validated to 2005 base year highway data only	2005	
v.3 - 2007 [β test version delivered 4/2007]	1. Updated mode choice ASC calibration using 2006 Household Interview Survey and 2006 Transit On Board Survey data 2. Repaired trip generation program and 3. Revised **2005** Socio Economic data provided by the MPOs.	**2005**	**1)** Transit Infrastructure Blueprint, **2)** the Chapel Hill Long Range Transit Plan, **3)** the Orange County Greenhouse Gas project and **4)** the Deficiency and Needs Analysis for the 2035 Long Range Transportation Plans.
v.4 - 2008 [Delivered 1/2008; approved spring; adopted 8/2008]	Improved v3-2007 ready for application and including HOV/HOT and toll capabilities.	**2005**	**1)** Alternatives Analysis and **2)** Air Quality Conformity Analysis for the 2035 Long Range Transportation Plans.

Version - Release Year [Delivered Time]	**Key Features Enhancements vs. Previous Version**	**Base Year**	**Use**
v.5 - 2011 Delivered 6/2011	**New:** 1. Parking capacity constraint 2. Airport trip making model 3. Bicycle and pedestrian travel submodels through trip distribution. 4. External station forecasts methodology. 5. Hourly capacity and traffic assignment 6. Use of Logsum in destination choice 7. Stratified utility coefficients by income in mode choice: 8. Summit analysis for FTA New Start analysis. [planned] 9. An off model GIS approach to forecast changes in road characteristics over time as rural areas become more urbanized [planned] 10. Travel by people from outside the region on transit. [planned] **Improved:** 1. Parking cost model improved; New: capacity constraint components added 2. Bus speed model: adjusted and validated vs. 2006 bus schedules. 3. Revise Federal Functional Class. Federal Functional Class has been updated in the 2010 v5 model to be consistent with NCDOT updates. **Investigated:** Cost of Auto Travel [e.g. gas price component]	2005, 2010	**1)** Alternatives Analysis and **2)** Air Quality Conformity Analysis for the 2040 Long Range Transportation Plans.

Appendix C

TRM Calibration and Validation Statistics

Triangle Regional Model components will be calibrated and validated to the following targets. These tests based on local and national targets will be used to evaluate the quality of model components.

Calibration/validation Statistics

Model Inputs

Model demographic data inputs will be checked against benchmarks at a regional level for persons/household, employment/population ratio, and autos/household. Plots of persons per household and household income by zone (TAZ) will be compared to census values. A report will document all findings.

Model highway and transit networks will be checked for reasonableness and the results will be reported. Maps of various network characteristics (area types, lanes, speeds, counts, screenlines, and transit routes by company) will be plotted to aid in the checks and to document the process used. The transit on board survey data will be assigned by access mode to the transit network and comparisons of transfer rates and assignments by transit line and company will be made to determine if problems exist. The results will be reported.

Model output from the household and person model (workers, non-workers, and children), and by household strata will be compared to census and other data for the region and sub region levels as appropriate (county and district) depending on the availability of data. This comparison will be documented in a report.

Trip Generation

Work trips per worker match survey work trips per worker

Ratio of region wide trip productions to trip attractions by trip purpose +/- 10%

Summaries comparing observed and model estimated trips by trip purpose will be prepared

Daily trips by trip purpose will be compared to determine if proportions of daily travel by purpose match survey data and proportions from other areas (benchmarks)

Overall trip rates by trip purpose will be compared to those reported for other areas

Trip productions per household and per capita will be compared to standard reasonable ranges

Summary comparisons will be made at the region, county, and district levels

Work trip attractions will be compared to total employment, K-12 school trips will be compared to total school enrollments, and shopping trips will be compared to total retail employment

Trip Distribution

Percent Deviation of Average Trip Length (minutes) for all trip purposes +/- 5%

District to district comparisons will be made of observed and model estimated trips. Trip length frequency distributions by time and distance will be prepared by trip purpose by strata. Coincidence ratios will be prepared for the trip length frequency distributions with a target of >70% coincidence.

Percent intra zonal trips by purpose will be compared to benchmarks.

Mode Choice

All trip purposes will match observed mode shares for auto and transit modes (+/- 2%), though not for transit by access mode to avoid over calibrating

Summaries by trip purpose will be prepared comparing observed mode shares to model estimated mode shares. Work trip mode shares will be compared to census (CTPP) mode share data. District summaries will be prepared. Auto occupancies will be compared to survey auto occupancies. Mean transit trip lengths will be compared to observed and these will be expected to fall within +/- 5%. Parameters will be compared to acceptable ranges.

Validation Statistics*

Vehicle Miles Traveled (VMT) by Federal Functional Class (based on links with counts)

Functional Class	Target % Deviation
Freeway	7%
Principal Arterial	10%
Minor Arterial	10%
Collector	15%
Local	15%
Total	5%

Screenline Comparison

Screenline Name	Target % Deviation
I-85	10%
I-40	10%
Wake/Durham County Line	10%

* All traffic counts used for validation will be factored in a consistent way

Cutline Comparison

Cutline Name	Target % Deviation
SW Durham	15%
Durham	15%
Johnston County	15%
Chatham County	15%
North Raleigh	15%
Eastern Wake	15%
US 1 South	15%
North Wake	15%
US 70	15%

* If unable to match this best practice target, then a secondary check will be performed based on the overall volume of the cutline

Percent Difference of Total Traffic Count Volume and Total Model Assigned Volumes by County and Area Type

Summary Level	% Difference Target (+/-)
County	
Durham	10%
Orange	10%
Wake	10%
Chatham	10%
Harnett	10%
Johnston	10%
Nash	10%
Franklin	10%

Granville	10%
Person	10%
Area Type	
Urban	10%
Suburban	10%
Rural	10%

Percent Difference of Model Estimated Daily Traffic Volumes by Federal Functional Class

Federal Functional Class	FHWA Target (+/-)	TRM Target (+/-)
Freeway	7%	5%
Principal Arterial	10%	8%
Minor Arterial	15%	10%
Collector	25%	15%
Local	25%	15%

Percent Difference of Model Estimated Daily Traffic Volumes by Volume Group

Volume Group	Target % Deviation
1 -1000	55%
1001 – 2500	50%
2501 – 5000	30%
5001 – 10000	25%
10001 – 25000	20%
25001 – 50000	15%
>= 50001	10%
Total	5%

R-Square for Region wide Estimated Volumes vs. Traffic Counts

Target R^2 >= 0.88

Root Mean Square Error (RMSE) of Estimated Traffic Volumes

Target RMSE <= 35%

Evaluation of Peak Period Assignments for AM and PM Peak Periods

Screenline Comparison AM and PM Peak

Screenline Name	Target % Deviation
I-85	10%
I-40	10%
Wake/Durham County Line	10%

Cutline Comparison AM and PM Peak

Cutline Name	Target % Deviation
SW Durham	15%
Durham	15%
Johnston County	15%
Chatham County	15%
North Raleigh	15%
Eastern Wake	15%
US 1 South	15%
North Wake	15%
US 70	15%

* If unable to match this best practice target, then a secondary check will be performed based on the overall volume of the cutline

AM and PM Peak Period Percent Difference of Total Traffic Count Volume and Total Model Assigned Volumes by County and Area Type Based on Links with Hourly Traffic Counts

Summary Level	% Difference Target (+/-)
County	
Durham	10%
Orange	10%
Wake	10%
Chatham	10%
Harnett	10%
Johnston	10%
Nash	10%
Franklin	10%
Granville	10%
Person	10%
Area Type	
Urban	10%
Suburban	10%
Rural	10%

Overall average speeds will be reported for AM peak, PM peak and off peak periods.

Transit Ridership Assigned

Total transit riders target +/- 5%

Target for individual companies +/- 10%

Transit riders by corridor +/- 15% for the following corridors:

US 15-501 between Chapel Hill and Durham

NC 147 between Durham and RTP

I-40 between Chapel Hill and RTP

US 1 North between Raleigh and Wake Forest

US 70 East between Raleigh and Garner

DCHC STAKEHOLDER BUDGET
TRIANGLE REGIONAL MODEL SERVICE BUREAU
BUDGET FOR YEAR 12: July 1, 2014 to June 30, 2015

Budget Items	Description of Level of Effort	Budget FY 2014-15
Salaries and Wages (Personnel) *		
ITRE Director	1.25 % effort for 12 mo	$ 1,538
Director	25 % effort for 12 mo	$ 24,188
Senior Research Associate	25 % effort for 12 mo	$ 19,914
Senior Research Associate	25 % effort for 12 mo	$ 19,730
Senior Research Associate	12.5 % effort for 12 mo	$ 7,635
Graduate Intern	50 % /sem; 100 % summer	$ 1,722
SUBTOTAL PERSONNEL		$ 74,727
Staff Benefits		
Staff (30%)		$ 21,902
Graduate Intern1 (21%)		$ 586
SUBTOTAL STAFF BENEFITS		$ 22,488
TOTAL PERSONNEL & BENEFITS		**$ 97,215**
Supplies and Materials		
(Supplies, plotter paper, plotter ink)		$ 50
		$ -
Travel		
In State		$ 138
Out of State		$ -
Training		$ 750
Current Services		
Communications (long distance)		$ 37
Printing and Binding		$ -
Contracted Services		
On-call technical assistance		$ 5,000
Household travel survey		$ 8,437
Transit on-board survey		$ -
Fixed Charges		
Rental of Equipment/State Vehicles		$ 75
Other Fixed Charges (software maintenance fees, $1,800/yr/key)		$ 2,450
Student Aid / Tuition Remission		
In State		$ -
Subcontract		
		$ -
TOTAL OTHER DIRECT COSTS		**$ 16,937**
Facilities & Administrative Costs		
20% of MTDC **		$ 22,830
TOTAL BUDGET		**$ 136,982**

* Uses a 3% growth factor/yr
** 20% based on one contract through the Master Agreement between NCSU-ITRE and NCDOT

Triangle Regional Model Service Bureau

Justification for Supplies and Materials

Plotter supplies are needed to support project plotting requirements.

Justification for Travel

Travel includes fees to cover project related training beneficial to the development of staff on the project.

Justification for Current Services

Current services covers the cost of long distance telephone communication.

Justification for Contracted Services

On-call technical assistance provides a way for the Service Bureau to obtain advice from technical experts in the field of travel forecasting. This enables the Service Bureau to learn how to appropriately implement new procedures consistent with national practice and experience.

The household survey will collect current travel behavior data to be used for estimating new models for the Triangle Region. The regional partners would like to collect travel behavior data every ten years, and the last data was collected in 2005-06 which suggests that data should be collected again during 2015. The data will be used to determine travel frequency, distance, and mode selected for travel.

The transit on board survey will collect current travel behavior for bus users to be used for calibrating mode choice models. Information to be collected will include trip origin and destination information, purpose for travel, and method for accessing transit services. This data was last collected in 2005-06 and needs to be collected during 2015 to be consistent with household travel data collected as noted above.

Justification for Other Fixed Charges

The maintenance of TransCAD software requires a $1,800 per year maintenance fee per license (including remote access). The Intel FORTRAN compiler license and technical support maintenance annual fee is $800 for two academic licenses.

Exhibit A.1
Percentage of Effort Estimate by Task

Triangle Regional Model

LABOR

HOURS BY PERSONNEL AND TASK
Triangle Regional Model Service Bureau - DCHC

TRM Service Bureau staff assigned	Raw Direct Labor Hourly Rate	1 Data collection	2 Model inputs	3 Trip generation	4 Time of day & peak spreading model	5 Trip distribution	6 Non-motorized	7 Mode choice	8 Special models	9 Trip assignment, calibration & validation	10 TRM Documentation	11 Technical assistance	12 Oversight reporting & training	Total Hours	Total Cost
		Estimated Level of Effort by Task													
ITRE Director	$76.93	3.0	7.4	0	0	0	0	0	0.9	2.4	0.5	1.7	4.1	20	$1,538
Director	$46.52	85.75	112	0	0	0	0	0	7.25	12	43	29.75	230.25	520	$24,188
Senior Research Associate	$38.30	59.75	330.25	0	0	0	0	0	0	0	4.75	53.75	71.5	520	$19,914
Senior Research Associate	$37.94	62	196.75	0	0	0	0	0	12	119.25	4.75	53.75	71.5	520	$19,730
Senior Research Associate	$29.36	7.25	83.75	0	0	0	0	0	38.75	65.25	2.4	26.9	35.75	260	$7,635
Student Intern	$16.00	107.6	0	0	0	0	0	0	0	0	0	0	0	107.6	$1,722
NCDOT Staff														0	
CAMPO Staff														0	
DCHC Staff		53	409	0	0	0	0	0	96	261		9		828	
Total Hours TRM Service Bureau		325	730	0	0	0	0	0	59	199	55	166	413	1928	
Total Hours Stakeholder Staff		53	409	0	0	0	0	0	96	261	0	9	0	828	
Total Task Hours		378	1139	0	0	0	0	0	155	460	55	175	413	2756	
Personnel cost by task		$10,796	$28,348	$0	$0	$0	$0	$0	$1,999	$7,183	$2,472	$6,405	$17,524		$74,727
Fringe Benefits @ 30%		$2,722	$8,505	$0	$0	$0	$0	$0	$600	$2,155	$741	$1,922	$5,257		$21,902
Intern Benefits @ 21%		$586	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0		$586
Total Labor with Fringe		$14,104	$36,853	$0	$0	$0	$0	$0	$2,599	$9,338	$3,213	$8,327	$22,781		$97,215

REIMBURSEABLE EXPENSES

Description	Total Cost
Supplies and Materials	
(Photocopying, plotter paper, plotter ink)	$50
Travel	
In State	$138
Out of State	$0
Training	$750
Current Services	
Communications (long distance)	$37
Printing and Binding	$0
Contracted Services	
On-call technical assistance	$5,000
Household travel survey	$8,437
Transit on-board survey	
Fixed Charges	
Rental of Equipment/State Vehicles	$75
Other Fixed Charges (software maintenance fees, $1,000/yr/key)	$2,450
Student Aid / Tuition Remission	
In State	$0
Total Reimburseable Expenses	$16,937
Subcontractors	$0
Facilities & Administrative Costs	
20% of MTDC **	$22,830
Total Hours	1928
Grand Total Labor	$97,215
Grand Total Subcontractors	$0
Grand Total Reimburseables	$16,937
Total Cost	$136,982

Exhibit B
Federal Regulatory and Programmatic Requirements
For Federal Flow-through Funding

Known State Funding Agency: NC Department of Transportation
Catalog of Federal Domestic Assistance (CFDA) Number: 20.205-5

By signing the agreement, the University Official certifies that to the best of his/her knowledge, University is in compliance with the applicable regulatory requirements listed below. University agrees to immediately report to Sponsor any change in its compliance status. University agrees to flow these requirements down to Subrecipient at any tier as appropriate.

1. Nondiscrimination statues on the basis of race, color, national origin, sex, blindness, handicap or age.
2. Common Federal Policy for the Protection of Human Subjects (45 CFR Parts 46 & 690).
3. USDA Rules that implement the Laboratory Animal Welfare Act of 1966 (9 CFR Parts 1-4).
4. Regulations for the Clean Air Act, 42 USC 7606, 40 CFR 6 & 32.
5. Regulations for the Clean Water Act 33 USC 1368, as implemented by E.O. 11738.
6. National Scenic Rivers Act of 1968, 16 USC1271, 40 CFR 6.
7. For NSF & DHHS awards only, internal conflict of interest policy.
8. E.O. 11246, & E.O. 11375 "Equal Employment Opportunity," per 41 CFR part 60.
9. OMB Circular A-129 and 40 CFR 30.73, the parties are not delinquent on any Federal debt.
10. The parties are in compliance with the Drug-Free Workplace Act of 1988, Public Law 100-690, 41 USC 701, 40 CFR 32 or equivalent.
11. HIPPA Patient Privacy Rule, 45 CFR 160 & 164.
12. Coastal Barriers Resource Act, 40 CFR 6.
13. The Anti-Kickback Act of 1986, Pub. L. 99-634, amending 18 U.S.C. 874, 29 C.F.R. Part 3
14. The Safe Drinking Water Act, 42 U.S.C. 300h-3(e)
15. Davis-Bacon Act, 40 U.S.C. 276a to 276a-7, 29 C.F.R. Part 5
16. Contract Work Hours and Safety Standards Act, 40 U.S.C. 327 – 330, 29 C.F.R. Part 5
17. Environmental Protection Agency Regulations, 40 C.F.R. Parts 1 through 49
18. Mandatory Standards & Policies contained in the State Energy Conservation Plan issued in compliance with the Energy Policy and Conservation Act, Pub. L. 94-163, 89 Stat. 871
19. "Debarment and Suspension" Regulations under E.O. 12549 & 12689, 7 CFR 3017, 10 CFR 606 & 40 CFR 32, or equivalent.
20. Prohibitions against lobbying as set forth in 7 CFR 3018, 31 USC 1352 and 18 USC 1913.
21. The Hatch Act (5 U.S.C. s 1501-1508 and 7324-7328) which limits the political activities of employees whose principal employment activities in whole or in part supported by Federal Funds.
22. Comply with environmental regulations that may be issued pursuant to:
    a. Institution of environmental quality control measures under NEPA (PL 91-190 & EO11514.
    b. Notification of violating facilities EO 11738
    c. Protection of wetlands EO 11990
    d. Evaluation of flood hazards in floodplains EO 11988
    e. Assure project consistency under Costal Zone Management Act of 1972 16 USC 1451
    f. Endangered Species Act of 1973, as amended PL 93-205
    g. National Historic Preservation Act of 1966, 16 USC470, EO11593
    h. Lead-Based Paint Poisoning Prevention Act 42 USC 4801
    i. Requirements governing the applicable Grant Program

(Abbreviations: CFR = "Code of Federal Regulations," USC = "United States Code," E.O. = "Executive Order," OMB = "Office of Management and Budget")

NORTH CAROLINA
DEPARTMENT OF INSURANCE
OSFM
OFFICE OF STATE FIRE MARSHAL

Exhibit C

Risk Management
Wayne Goodwin | Commissioner of Insurance

July 15, 2013

Mr. Matthew K. Ronning
Associate Vice Chancellor for Research Administration
Research Administration/SPARCS
North Carolina State University
Campus Box 7514
Administrative Services Building I
Raleigh, NC 27695-7514

Dear Mr. Ronning:

The purpose of this letter is to provide certification of various insurance coverages for North Carolina State University.

Property insurance is provided on a replacement cost basis by the State Property Fire Insurance Fund, a State self-insurance fund. This coverage is provided on a continuous basis and renews on July 1 of each year. We do not use policy numbers. Instead, we refer to the University's department/division number, which is 60005003.

In regard to general liability, the State of North Carolina claims sovereign immunity and therefore cannot be sued without its permission. However, by statute (Chapter 143, Article 31), the State has waived its sovereign immunity against suits for negligence of its employees or agents resulting from bodily injury or property damage. The State has waived its immunity up to a limit of $1,000,000 per claim. The North Carolina Industrial Commission is constituted a court for the purpose of hearing and passing upon tort claims against departments, institutions or agencies.

Excess liability coverage is provided for State employees, through a private insurance company, for losses resulting in bodily injury and property damage in the performance of their jobs. The limit of liability is $10,000,000 per occurrence.

The State maintains a boiler and machinery policy written through the Hartford Steam Boiler Inspection and Insurance Company. The renewal date for this policy is January 12 and the limit of coverage is $50,000,000 for each accident with a $5,000 deductible (certain equipment may carry a higher deductible).

Automobile liability insurance for state-owned vehicles is provided by Travelers. The bodily injury and property damage limits for this coverage is $1,000,000 per person and $10,000,000 per occurrence. This policy renewal date is July 1.

Public Employee Dishonesty coverage is written through Fidelity and Deposit Company of Maryland with a $1,000,000 limit. The policy renews on January 6.

The State of North Carolina is self-insured for the payment of Workers Compensation claims.

Sincerely,

L. Jack Cooke

L. Jack Cooke, CPCU
Director of Risk Management

RISK MANAGEMENT DIVISION

Wayne Goodwin | Commissioner of Insurance

CERTIFICATE OF COVERAGE

CERTIFICATE HOLDER:	For Information Purposes Only
Insurer:	State of North Carolina
Authorization:	Public Officers & Employee Liability Insurance Commission of North Carolina and the General Statutes of North Carolina, Sections §143-291 to §143-305.
Period:	July 1, 2013 until June 30, 2014
Coverage:	A) Tort Claims against Departments, Agencies, and Employees B) Excess Liability for State Employees C) Workers Compensation.
Limits	A) $1,000,000 for Tort claims against the State B) $10,000,000 for claims against state employees C) Statutory Limits for Workers' Compensation
Description:	North Carolina State University; and its employees, officers, agents, as covered by the Defense of State Employees
Administrator:	Department Insurance - Risk Management Division Public Officers & Employees Liability Insurance Commission 1202 Mail Service Center Raleigh, NC 27699-1202
Note:	This Certificate is for informational purposes only and does not alter any provision of the Tort Claims or Defense of State Employees General Statutes of the State.

Verified By: _____

Joseph D. Rippard, CPCU
Risk Manager

NCSU-Certificate 2014 doc

AUTOR-1 OP ID: KK

ACORD

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY) 06/26/13

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER	CONTACT NAME:	
NC Assoc. of Ins. Agents, Inc. P. O. Box 1165 Cary, NC 27512 Karen A. Kerr, AAI, CISR, CPIW	PHONE (A/C, No, Ext):	FAX (A/C, No):
	E-MAIL ADDRESS:	

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : Travelers Property & Casualty	
INSURER B :	
INSURER C :	
INSURER D :	
INSURER E :	
INSURER F :	

INSURED: State of North Carolina
Attn: Joe Rippardl
102 Mail Service Center
Raleigh, NC 27699-1202

COVERAGES **CERTIFICATE NUMBER:** **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
	GENERAL LIABILITY						EACH OCCURRENCE	$
	☐ COMMERCIAL GENERAL LIABILITY						DAMAGE TO RENTED PREMISES (Ea occurrence)	$
	☐ CLAIMS-MADE ☐ OCCUR						MED EXP (Any one person)	$
							PERSONAL & ADV INJURY	$
							GENERAL AGGREGATE	$
	GEN'L AGGREGATE LIMIT APPLIES PER:						PRODUCTS - COMP/OP AGG	$
	☐ POLICY ☐ PRO-JECT ☐ LOC							$
	AUTOMOBILE LIABILITY						COMBINED SINGLE LIMIT (Ea accident)	$
A	X ANY AUTO			TRJCAP104T6800TIL-13	07/01/13	07/01/14	BODILY INJURY (Per person)	$ 1,000,000
	☐ ALL OWNED AUTOS ☐ SCHEDULED AUTOS						BODILY INJURY (Per accident)	$
	☐ HIRED AUTOS ☐ NON-OWNED AUTOS						PROPERTY DAMAGE (Per accident)	$ INCL ABOVE
							BI/PD PER ACC	$ 10,000,000
	☐ UMBRELLA LIAB ☐ OCCUR						EACH OCCURRENCE	$
	☐ EXCESS LIAB ☐ CLAIMS-MADE						AGGREGATE	$
	☐ DED ☐ RETENTION $							$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY						WC STATU-TORY LIMITS ☐ OTH-ER	
	ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? Y/N ☐ (Mandatory in NH)	N/A					E.L. EACH ACCIDENT	$
	If yes, describe under DESCRIPTION OF OPERATIONS below						E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$
A	Hired Physical Damage			TRJCAP449J9525TIL-13	07/01/13	07/01/14		

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (Attach ACORD 101, Additional Remarks Schedule, if more space is required)

RE: Hired Physical Damage Limits: ACV, cost of repair or $30,000 ($50,000 if GVW exceeds 10,000 lbs.), whichever is less. Comp and Collsiion coverage only apply for 30 days from the date the rental contract becomes valid.

CERTIFICATE HOLDER

NCDEPTO

NC Dept. of Insurance
Attn: Joe Rippard
1202 Mail Service Center
Raleigh, NC 27699-1202

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE

Karen A. Kerr

Exhibit A.2
Schedule Effort by Task, Subtask and Timeline

Schedule

FY 2014/2015

Task	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1.1 Advice on parking behavior data collection	■	■	■	■								
1.2 Household survey data collection	■	■	■	■	■	■	■	■	■	■	■	■
1.3 Transit on-board survey data collection	■	■	■	■	■	■	■	■	■	■	■	■
1.4 Gather locally collected data	■	■	■	■	■	■	■	■	■	■	■	■
2.1 Maintain & update highway & transit networks, SE data	■	■	■	■	■	■	■	■	■			
2.2 Modify Net Manager to work with v6 networks								■	■			
2.3 Zone geography												
2.4 Develop highway network procedures												
2.5 Transit networks												
2.6 Zonal data and models									■	■	■	
2.7 Develop an improved parking constraint model	■	■	■	■	■	■	■	■	■	■	■	■
2.8 Data systems											■	■
3.1 Estimation and/or calibration of trip production models												
4.1 Peak spreading models												
4.2 Prepare time of day factors												
5.1 Develop improved destination choice model												
6.1 Calibration and/or estimation of non-motorized models												
7.1 Re-calibration of mode choice models												
8.1 Develop improved commercial vehicle model												
8.2 University student model	■	■	■	■	■	■						
8.3 Land use models												
8.4 External travel models							■	■				
8.5 Links to MOVES air quality models										■	■	■
8.6 Sub-area and corridor analysis procedures										■	■	■
9.1 Investigate improving highway assignment												
9.2 Highway assignment	■	■	■	■	■	■						
10.1 TRM v6 documentation							■	■	■	■	■	■
11.1 Assist with LRTP model application	As needed											
11.2 Assistance with TRM model application	As needed											
11.3 Action items	As needed											
12 Oversight, reporting & training	■	■	■	■	■	■	■	■	■	■	■	■

Exhibit A.2
Schedule Effort by Task, Subtask and Timeline